STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
Pullman, Washington

Division of Plant Pathology

The Mosaic Disease of Beets

by

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BULLETIN No. 250

March, 1931

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THE MOSAIC DISEASE OF BEETS

By

Leon K. Jones

Introduction

The production of garden beet seed in the United States is largely limited to sections in California and Washington. There is annually an average of 1200 to 1500 acres in Skagit County, Washington, devoted to beet seed production. During 1929 a decreased production of beet seed in Skagit County was first brought to the attention of the Department of Plant Pathology. It was contended by growers and seedsmen that the average yield of seed per acre was at least 50 per cent less than was the yield about 5 years previously.

In tests made on mother beets in the greenhouse during the spring of 1929 and followed by field observations during the summer of 1929 it was noted that a large percentage of the beets was affected with mosaic. Many of the fields of mother-beets showed 100 per cent of the plants infected with this disease. This condition, no doubt, would account for a large reduction in yield of seed resulting from lowered vitality and early maturing of the plants.

Distribution of the Disease

The mosaic disease of beets was first noted (12)* in 1898 on garden beets in northern France and in the vicinity of Paris. Reports on this disease have been made in Denmark (9, 13, 16), in Germany (3-6, 17), and in Sweden (8) on sugar beets and garden beets. The disease was first reported in the United States in 1915 (19), having been observed on sugar beets in northern Colorado and western Nebraska. The Plant Disease Reporter of the United State Department of Agriculture records the occurrence of this disease in Utah and New Mexico in 1927, Utah and Texas in 1928, and Washington in 1929.

* Reference is made by number to literature list, page 16.

A survey of the seed-beet plantings in Skagit County was made June 13, July 17, and again on September 3, 1930. Fifty-one fields of mother beets, representing about 266 acres, were visited. Mosaic was found to be present in every planting visited. The survey on June 13 recorded 10 fields having 1 to 10 per cent, 11 fields having 11 to 25 per cent, 8 fields having 26 to 50 per cent, 9 fields having 51 to 75 per cent, and 13 fields having 76 to 100 per cent of the plants infected with mosaic. The disease could be easily detected on the plants June 13, but as the season progressed it became very hard to diagnose the symptoms of disease. On July 17, and September 3 it was noted that red spotting of the foliage, possibly caused by insect injury, often made it impossible to determine definitely the presence of mosaic. Estimates on the percentage of mosaic-infected beet plants in the seedling plantings were attempted on September 3 (Table 1), although considerable latitude in the estimates must be allowed because the plants often do not show definite symptoms of the disease at that time of the year. In order to check on the reliability of the estimates, from 20 to 60 seedling beets from 4 of the fields were sent to Pullman and grown in the greenhouse. One lot estimated as being 75 to 90 per cent infected in the field showed 77 per cent infection in the greenhouse (60 plants grown in greenhouse). Another lot estimated as containing 2 to 5 per cent mosaic in the field showed no mosaic on 25 plants in the greenhouse. A further lot having a field estimate of 15 per cent mosaic showed 10 per cent infection with 20 plants in the greenhouse.

Cause of the Disease

In 1898 workers in France (12) considered the disease of bacterial nature, and reported successful inoculations to prove that bacteria could cause the disease. The early investigators in Europe referred to the disease as "yellows" or "jaundice," but recognized the similarity of the symptoms exhibited by diseased beets to the symptoms of the mosaic disease of tobacco. Since 1921 (14, 15) it has been definitely proven that this disease is caused by a virus and is of the general nature of other mosaic diseases.

Mosaic diseases are caused by an unknown entity that may be transmitted from one plant to another. The infective principle will,

in general, pass through very fine filters. These filters will not allow the smallest organisms that we can see with a microscope to pass through into the filtrate.

The first mosaic disease of plants was described in Holland (10) in 1886 on tobacco. It has been demonstrated that the sap from diseased plants is capable of causing the disease in healthy plants. Further work has demonstrated that sap from diseased plants when passed through a bacteria-proof filter remains infectious. It has since been shown that the infective mosaic particles may be one three-hundredth the average diameter of bacteria or a ratio of 1:37,000 in volume. Investigations have shown that insects can act as carriers of certain virus diseases. Many insects are capable of transmitting various virus diseases. Aphids or plant lice are capable of transmitting more virus diseases than any other type of insect. Many virus diseases may be spread by mechanical means such as rubbing the sap from one plant on another, while others require insects for their transmission from plant to plant.

Description of the Disease

The symptoms of the disease vary on different plants and under various light and temperature conditions. Leaves on affected plants tend to show puckering and crinkling with a wavy margin (Figure 1, B). Such leaves are often abnormally thick and brittle. Affected plants are somewhat dwarfed in growth. Small, circular to irregular, light green to grey areas, 1-2 mm. in diameter, may be scattered over the interveinal tissue. These light areas may have a definite reddish margin (Figures 2, C and 3, A), or the reddish margin may be lacking (Figure 2, A). These light areas may be diffuse and irregular or they may be very definite and circular. Plants affected in this manner have a lighter green, somewhat yellowish color. Some leaves may show scattered red blotches in the interveinal tissue with reddish coloration along the veins (Figure 3, C). The above symptoms are to be found on plants grown at 70°F. In general, plants grown at 50°F. show very indefinite symptoms of the disease. The leaves have a darker green or reddish color. Light green circular spots with faint reddish margins or a mild yellowish-green diffuse mottling may be present. Other leaves merely show abnormal diffused reddish color with a few scattered circular, 1-2 mm., light green spots that appear slightly sunken.

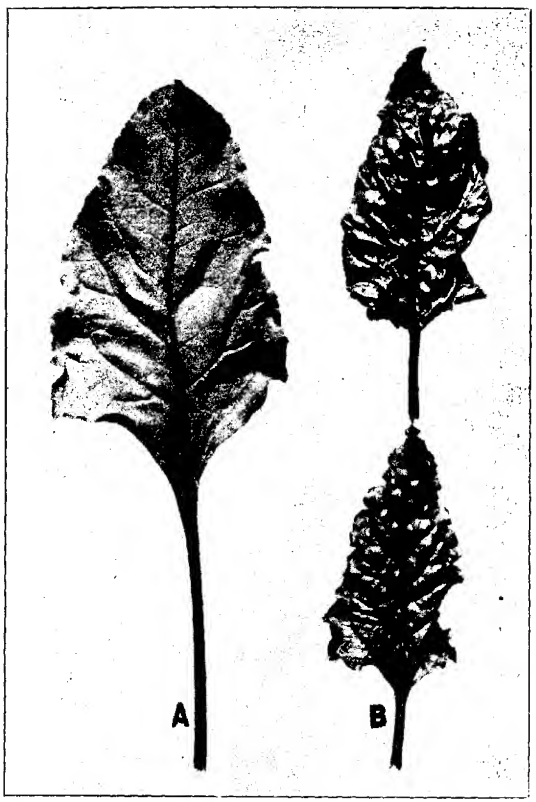

Figure 1. Foliage from Early Crosby beet plants.
A. Healthy leaf.
B. Wrinkled and dwarfed leaves from mosaic infected plants.

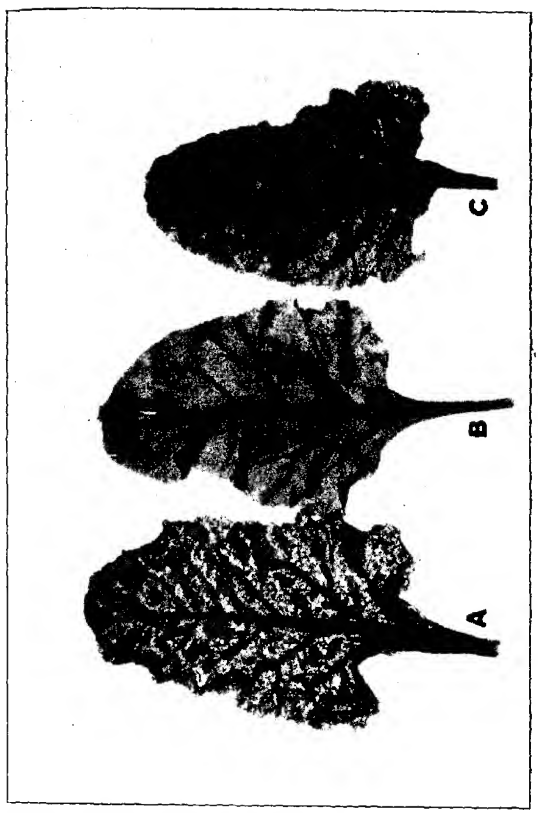

Figure 2. Foliage from Early Crosby beet plants.
A. Mosaic mottling of foliage without red coloration.
B. Leaf from healthy beet plant.
C. Mosaic mottling of foliage with red margins on the light green circular areas.

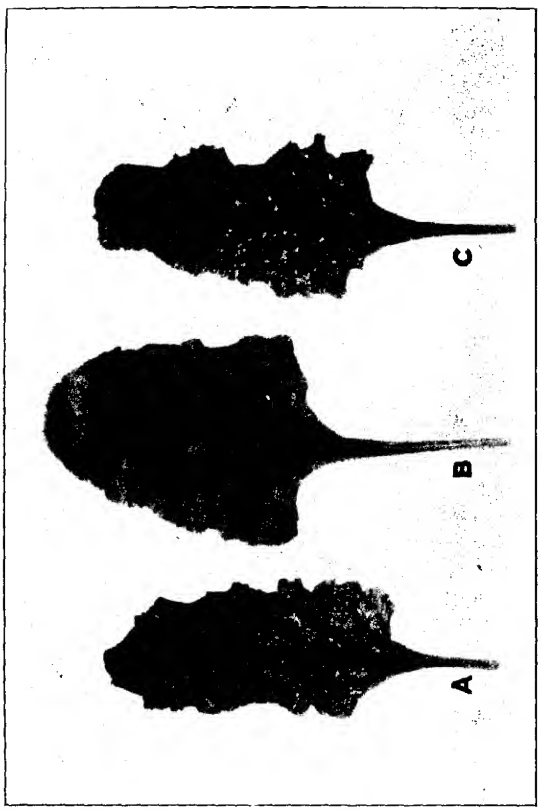

Figure 3. Foliage from Early Blood Turnip beet plants.
A. and C. Leaves from mosaic infected plants.
B. Leaf from healthy plant.

Mother-beet plants in the field were observed to become mature with dead and dying foliage nearly one month earlier than healthy plants. Early maturing of the plants accounted for a poorer set of seed and smaller seed on the diseased plants than was the case with healthy plants.

Transimssion of the Disease

The disease evidently cannot be transmitted by placing juice from mosaic plants into wounds on healthy plants. Negative results with such tests have been reported in Germany (6) and by Robbins (15) in the United States. Robbins further states, "up to date, all attempts to transfer the disease by means of needle inoculations, by the injection of freshly prepared juice with a hypodermic needle, and by the insertion of freshly crushed fragments of mosaic leaves into slits on the leaf petioles and crown, have been unsuccessful." Experimental evidence produced in Germany (6) show that the disease will not live in the soil. The workers in Germany (6) were unable to observe any spread of the disease through plant contact in the field.

Experimental work in Denmark (9), in the United States (15), and in Germany (6) has led to the conclusion by each worker that the disease is not carried in the seed. The writer collected seed from mosaic infected beet plants in 1929. One thousand plants were grown from this seed in the greenhouse and no sign of mosaic was noted on these plants.

An investigator in Denmark (9) in 1915 suspected that beet mosaic could be transmitted by plant lice, bugs, and earwigs. He did not, however, carry on investigational work to prove his contention. Robbins (15) was able to transmit the disease from mosaic infected plants to healthy plants with the common greenhouse aphid *(Myzus persicae)*. Böning and Schaffnit (6) report successful transmission of the disease with the black louse *(Aphis fabae)* and state that other green lice as well as the common greenhouse aphid might transmit it. Böning (3) further reports the transmission of beet mosaic with *Macrosiphum* sp. as well as with the black louse.

It was noted in Germany (6) that the black louse was readily found in the spring and early summer on the horse bean *(Vicia faba)*. They also noted that this aphid spent the winter on the spindle tree *(Evonymus* spp.*)*.

Further investigational work is advisable to determine the species of aphids found on beets in Skagit county. A study of the life history of these aphids may assist in locating possible sources of infection in the field.

In July 1929 the writer transferred aphids from mosaic beet plants to 25 healthy seedling beets. Ten aphids were placed on each seedling. The common greenhouse aphid was used. Ten healthy seedling beets were treated in the same way except that aphids were taken from healthy beet plants. Seventeen days after the aphids were placed on the seedling beets observations showed the disease appearing on the young leaves of all the seedlings carrying aphids from diseased plants. The ten plants carrying aphids from healthy plants remained free from the disease.

Spread of the Disease

During the survey of 1930 only a small amount of spread of the disease in the mother-beet plantings was noted prior to July 17. The seedling beets were very small on July 17, and no disease was noted on the young plants. Between July 17 and September 3 the disease spread quite rapidly, especially in the seedling plantings.

These observations are similar to those reported by Robbins (15) in his investigations of sugar beet mosaic. He noted 3 per cent of the plants in a block of beets affected with mosaic on July 3; 5 per cent, July 14; 11 per cent, July 29; 15 per cent, August 6; 23 per cent, August 21; 50 per cent, August 28; and 60 per cent, September 15. Similar observations have been made (6) in Germany.

Up to the present time all experimental work shows that the spread of the diseases in the field is dependent upon aphids. Other insects may possibly spread the disease, although there is no experimental evidence that such is the case.

During the field survey of 1930 it was noted that aphids were practically absent from the beet plants on June 13, a few green aphids were on the plants on July 17, and both the green and black aphids were fairly abundant on the plants on September 3.

Observations tend to show that there is little increase in the percentage of diseased plants during the early summer months and that the disease may spread rapidly during the later months of summer, dependent upon the prevalence of aphids.

Robbins (15) showed that a diseased mother-beet planting may serve as a source of infection for adjacent plantings of healthy beets. The closer the healthy beets are to the diseased planting, the greater is the spread of the disease to the healthy plants. He obtained data on 3 plots of seedling beets adjacent to infected mother-beet plantings. At the time of harvest the first rows of seedling beets in each plot adjacent to the mother beets contained 79, 79, and 92 per cent of the plants affected with the disease. The sixteenth rows from the mother beets in the 3 plots contained 21, 26, and 52 per cent of the plants affected with mosaic. Similar observations were made by the writer in field 21 reported in Table 1. The seedling beets were planted adjacent to mother beets that were 40 per cent affected with mosaic. The plot of seedling beets was rectangular in shape, extending some 150 feet from the mother beets. The seedlings adjacent to the mother beets showed 25 per cent of the plants affected with mosaic. Only 5 per cent of the seedling beets about 150 feet from the mother beets were affected when observations were made on September 3.

In the survey of September 3 it was further evident that seedling-beet plantings adjacent to affected mother-beet plantings were more heavily infected with the disease than were seedling plantings that were 100 yards or more from mother beets. These observations are shown in Table 1. The average percentage of disease in seedling plantings adjacent to mother-beet plantings was 59, while an average of 6 per cent disease was found in seedling plantings that were at least 100 yards from affected mother beets.

Robbins (15) observed the transmission of mosaic to seedling beets to a maximum distance of one and one-half miles from diseased beets. However, the diseased plants at that distance were very few in number.

A further observation made during the survey in 1930 may be of considerable value. The beet growing area extends southwest of Mount Vernon to the waters of Puget Sound. In the area approaching the water very little mosaic was noted in any of the beet plantings. During the summer the prevailing winds blow from the water. This wind from the water does not carry in aphids, and may aid in keeping aphids from becoming established on the plants in that area. On June 13 there was an average of only 4 per cent infection in 8 beet plantings

from mother beets produced in that area the previous season, as compared with an average of 52 per cent infection in 43 plantings from beets produced in the rest of the beet growing territory.

It has been shown (15) that the disease lives over winter in the beets in the pits. No other mode of overwintering has been demonstrated. The possibility of the disease overwintering on weeds has not been investigated.

Host Range

The disease has been noted on spinach, garden beets, sugar beets, and mangels. During the spring of 1929 the writer attempted to transmit the disease to tomato and potato plants as well as to beet plants. Tweny plants each of tomatoes, potatoes, and beets were used. The common green aphid *(Myzus persicae)* was transferred from diseased beet plants to 10 each of the three kinds of plants. At the same time aphids were transferred from healthy beet plants to 10 plants each of tomato, potato, and beets. The plants carrying the aphids from healthy beets and the tomato and potato plants carrying the aphids from mosaic

Table 1. Results of Survey of Seedling Beet Fields for Beet Mosaic, Mount Vernon, Washington, September 3, 1930

Seedlings grown adjacent to mother beets			Seedlings grown at least 100 yards from mother beets	
Field Number	Per cent having mosaic		Field Number	Per cent having mosaic
	Mother beets	Seedling beets		
4	95	85	52	12
5	15	85	53	5
10	20	90	54	15
16	75	70	55	1
21	40	15	56	3
34	95	95	24	2
42	100	80	29	1
44	35	5	45	7
49	2	3		
Average	50	59		6

beet plants remained normal in appearance for 45 days. The beet plants carrying aphids from the diseased beet plants showed symptoms of mosaic from 12 to 15 days after the aphids were placed upon them.

Curly-top of Beets

There is another virus disease of beets present in the Skagit County beet-growing area. This disease is known as curly-top of beets. Curly-top of beets has been very destructive in sugar-beet plantings in the semi-arid districts of western United States. This disease is transmitted from plant to plant by the leaf hopper *(Eutettix tenella)*. The outstanding symptom of the curly-top disease is an in-rolling and curling of the leaves (Figure 4, B) and vein distortion. The outstanding symptom of beet mosaic is a pronounced mottling of the leaves, which symptom is not evident in curly-top.

During the survey of 1930, 2 to 5 per cent of the beet plants in most of the plantings were found to be affected with the curly-top disease. Plants grown in the greenhouse during early winter of 1930 and produced in field 34 (Table 1) showed 27 per cent infection with this disease. Seedling plants in field 4 showed 15 per cent infection with curly-top in greenhouse tests.

Further investigations on this disease in Skagit County, Washington, should be undertaken.

Summary and Conclusions

The yield of beet seed from 1200 to 1500 acres devoted to this industry has been greatly reduced during the past 5 years.

A virus disease known as mosaic has been found to be very prevalent in the beet-seed growing area. This disease, no doubt, is a large factor in causing reduced yields.

Mosaic of beets has been reported as occurring in France, Denmark, Sweden, and Germany, and in Colorado, Nebraska, Utah, New Mexico, Texas, and Washington of the United States.

The outstanding symptoms of the disease are: dwarfing and early maturing of plants and mottling of the foliage, with light and dark green areas often accentuated by various types of red spots.

The disease is transmitted from diseased to healthy plants by aphids.

Figure 4. Young seedling Early Crosby beet plants.
A. Healthy plant.
B. Plant affected with the Curly-top disease.

The disease apparently cannot be transmitted through plant contact, transfer of sap to wounded plants, or in seed from diseased plants.

The disease apparently does not live in the soil.

The disease will live over winter on the beet roots in the pits, and such infected mother-beets act as a source of infection when planted in the field the following spring.

Mosaic of beets spreads most rapidly during the latter part of the summer.

It has been shown that the closer seedling beets are grown to infected mother beets, the greater is the spread of the disease to the seedlings.

The disease has been observed to be transmitted sparingly at least one and one-half miles from infected plantings.

Seedling beets should be planted at least 100 yards from mother beets, and greater distances between plantings are desirable.

Beets grown southwest of Mount Vernon near the waters of Puget Sound are relatively free from mosaic. It would be advisable to concentrate the growing of seedlings in that area. Roots grown there the first year could be transferred to the larger area for seed production during the second season.

Beet mosaic has been noted on garden beets, sugar beets, mangels, and spinach. The author was unable to transfer the disease to tomato or potato. No further investigations have been reported on the host range of this disease.

Curly-top of beets, another virus disease, is present in Skagit County. This disease has been very destructive on sugar beets in the semi-arid western part of the United States.

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